2.2 Water Quality

2.2.1 Water Quality Standards and Criteria

Water quality standards under the Clean Water Act consist of three main components: designated beneficial uses, water quality criteria that are established to protect designated beneficial uses, and antidegradation policies and procedures. Water quality criteria can be either numeric limits for individual pollutants and conditions, or narrative descriptions of desired conditions. Table 2.2.1 summarizes the Oregon and Idaho water quality criteria and lists specific citations where the full code language can be found. Because of the bi-state nature of the SR-HC TMDL, and the fact that the Snake River from RM 409 to RM 188 is an interstate water body with the state boundary line described as the centerline of the river, water quality standards and particularly water quality criteria for both Oregon and Idaho must be attained. Because the state line between Oregon and Idaho is in the middle of the mainstem Snake River, the waters of both states are mixed mid-river. Therefore waters from both sides must meet the criteria of both states in the mainstem.

The CWA regulations require that state water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters. There is a precedent set by the Dioxin TMDL for the Columbia to use the more stringent standards of a bi-state system. In addition, in the Coeur d'Alene TMDL, WLAs were set to ensure that downstream water-quality criteria would be met. The US Supreme Court ruling in Arkansas v. Oklahoma provided that US EPA has the authority to require discharges from NPDES permitted facilities to comply with downstream state standards.

Due to the fact that the states of Oregon and Idaho use different methodologies to determine what constitutes a violation of water quality standards and to calculate whether or not a violation of state standards has occurred, it is not immediately obvious which state's standards represent the most stringent values. A direct calculation of stringency was therefore undertaken for standards for which numeric criteria had been established. In the case of those pollutants where numeric criteria were not available, reasonable state and federal guidelines and guidance documents have been applied in correlation with the current understanding of the system and the physical constraints imposed by naturally occurring conditions. A copy of the stringency analysis generated is attached in Appendix C. The resulting water quality targets for the SR-HC TMDL are listed in Table 2.2.2.

Please note, the identification of stringency and the use of Oregon or Idaho State standards determined to be the more stringent as a basis for the identification of water quality targets for the SR-HC TMDL should not be interpreted as applying Idaho State standards to Oregon waters or v/v per se. Rather, this mechanism is being used to ensure that both states' standards will be met at the border (mid-river) where the two states' waters meet.

Table 2.2.1 Idaho and Oregon water quality standards and criteria summary

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Bacteria	Less than 126 *E. coli* organisms/100 mL as a 30 day log mean with a minimum of 5 samples **AND** no sample greater than 406 *E. coli* organisms/100 mL	251.01.a & b	Less than 126 *E. coli* organisms/100 mL as a 30 day log mean with a minimum of 5 samples **AND** no sample greater than 406 *E. coli* organisms/100 mL	340-41-725, 765, 805, 845 (2) (e)(A)
Dissolved Oxygen (DO)				
Cold Water Aquatic Life	Greater than 6.0 mg dissolved oxygen/L; except in hypolimnion of stratified lakes and reservoirs and the bottom 7 meters in lakes and reservoirs with greater than 35 m depth **Site-specific criteria**: a minimum of 6.5 mg/L water column dissolved oxygen from the Idaho/Oregon border to Hells Canyon Dam. (approved by the Idaho Legislature 20 March 2004, subject to US EPA action)	250.02.a 285.Snake River, Subsections 140.13, HUC 17050115, unit SW1; and 140.19, HUC 17050201, units SW1 - SW4	8.0 mg dissolved oxygen/L **OR** (where conditions of barometric pressure, altitude, and temperature preclude attainment of 8 mg/L) dissolved oxygen levels shall not be less than 90% saturation as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	340-41-725, 765, 805, 845 (2) (a) (D)
Cool Water Aquatic Life	N/A		6.5 mg/L as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	340-41-725, 765, 805, 845 (2) (a) (E)
Salmonid Spawning	Water column dissolved oxygen of not less than 6.0 mg/L or 90% of saturation whichever is greater.	250.02.e.2.a	Water column dissolved oxygen of not less than 11.0 mg/L OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95% of saturation (if adequate data exists a water column criteria of 9 mg/L if the intergravel dissolved oxygen is greater than 8 mg/L)	340-41-725, 765, 805, 845 (2) (a) (A)
	Intergravel dissolved oxygen of not less than 5 mg/L (1 day min) **AND** not less than 6.0 mg/L (7 day avg. mean) during spawning and incubation period for species inhabiting the waters	250.02.e.1	Intergravel dissolved oxygen of not less than 6 mg/L	340-41-725, 765, 805, 845 (2) (a)(B)

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Salmonid Rearing	N/A		N/A	
Seasonal Cold	Greater than 6.0 mg dissolved oxygen/L; except in hypolimnion of stratified lakes and reservoirs and the bottom 7 meters in lakes and reservoirs with greater than 35 m depth, applicable during the time period from the summer solstice to the autumnal equinox	250.03.a.i-iii	N/A	
Warm Water Aquatic Life	Greater than 5.0 mg dissolved oxygen/L; except in hypolimnion of stratified lakes and reservoirs and the bottom 7 meters in lakes and reservoirs with greater than 35 m depth	250.04.a	5.5 mg/L as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards	340-41-725, 765, 805, 845 (2) (a) (F)
Mercury	Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses. Toxic substance criteria is set forth in CWA 40 CFR 131.36 (b)(1) (National Toxics Rule (NTR)). 0.012 ug/L water column concentration aquatic life chronic criterion	210	Toxic substances will not be introduced above natural background levels in the waters of the state which may be harmful, may chemically change to harmful forms in the environment, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect public health, safety, or welfare (2.4 mg/L for acute aquatic exposure and 0.012 mg/L for chronic aquatic exposure)	340-41-725, 765, 805, 845 (2) (p)(A)
	0.14 ug/L water column concentration for ingestion of fish and drinking water	210 and National Toxics Rule (CWA 40 CFR 131.36 (b)(1)	Less than 0.144 ug/L water column concentration for ingestion of fish and drinking water	340-41-725, 765, 805, 845 (2)(p)(B) which references Table 20
	1.0 mg/kg total mercury (NTR), less than 0.5 mg methylmercury /kg in fish tissue (wet weight) for human consumption	210 and National Toxics Rule (CWA 40 CFR 131.36 (b)(1)) Idaho Dept. of Environ. Health and Safety	Less than 0.35 mg Hg/kg in fish tissue	340-41-725, 765, 805, 845 (2) (p)(A) as interpreted by the Oregon Health Division

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Nuisance Algae	Surface waters shall be free from floating, suspended or submerged matter of any kind in concentrations causing nuisance or objectionable conditions or that impair designated beneficial uses and be free from oxygen-demanding materials in concentrations that would result in an anaerobic water condition.	200.05 & 07	A threshold level of less than 0.015 mg chlorophyll *a*/L which when exceeded should trigger a Department determination of impairment of a designated use. (This TMDL represents that determination and contains site-specific targets for protection and support of the designated uses)	340-41-150 (1)(b) and 340-41-725, 765, 805, 845 (2)(h-l),
Nutrients	Surface waters shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses.	200.06	Addressed by watershed if chlorophyll *a* action levels are not met or there is evidence through dissolved oxygen or pH problems that a designated use is being impaired.	
Pesticides	Surface waters of the state shall be free from toxic substances in concentrations that impair designated beneficial uses. Toxic substance criteria is set forth in CWA 40 CFR 131.36 (b)(1) (National Toxics Rule).		Toxic substances shall not be introduced above natural background levels at levels that may be harmful, may change to harmful forms, or may accumulate in sediments or bioaccumulate in aquatic life or wildlife to levels that adversely affect designated beneficial uses.	340-41-725, 765, 805, 845 (2)(p)(A-D); Table 20 criteria
DDT	Less than 0.00059 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	Less than 0.000024 ug/L water column concentration for ingestion of fish and drinking water	Table 20 criteria
DDD	Less than 0.00083 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	N/A	
DDE	Less than 0.00059 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	N/A	
Dieldrin	Less than 0.00014 ug/L water column concentration for ingestion of fish and drinking water	210 and Nat. Toxics Rule (CWA 40 CFR 131.36 (b)(1))	Less than 0.000071 ug/L water column concentration for ingestion of fish and drinking water	Table 20 criteria

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
pH	6.5 to 9.0 standard units	250.01.a	7.0 to 9.0 standard units. From RM 260 to 409 reservoirs impounded prior to 1996 are exempt from this criterion if the pH numeric criteria would not have been exceeded without the impoundment and all practicable measures have been taken to bring the pH into compliance with the criteria.	340-41-725, 765, 805, 845 (2)(d)
Temperature				
Cold Water Aquatic Life	Water temperatures of 22 °C or less with a maximum daily average of no greater than 19 °C	250.02.b	N/A	
Salmonid Spawning (criteria are specific to those spawning periods designated as appropriate for the specific species present)	Water temperatures of 13 °C or less with a maximum daily average no greater than 9 °C **Site-specific criteria:** A maximum weekly maximum temperature of 13 °C to protect fall chinook spawning and incubation applies from October 23rd through April 15th in the Snake River from Hell's Canyon Dam to the Salmon River. (Temporary rule, effective by action of the IDEQ board 11-14-03, pending approval by Idaho Legislature 2005, subject to US EPA action)	250.02.e.ii 286.Snake River, Subsection 130.01, HUC 17060101, Unit S1 to S3.	12.8 °C or less as a 7-day moving average of the daily maximum temperature	340-41-725, 765, 805, 845 (2)(b)(A &B)
Salmonid Rearing	N/A		17.8 °C or less as a 7-day moving average of the daily maximum temperature	340-41-725, 765, 805, 845 (2)(b)(A &B)
Seasonal Cold	Water temperatures of 26 °C or less as a daily maximum with a daily average of no greater than 23 °C, applicable during the time period from the summer solstice to the autumnal equinox	250.03.b	N/A	
Warm Water Aquatic Life	Water temperatures of 33 °C or less with a maximum daily average not greater than 29 °C	250.04.b	N/A	

Parameter	Idaho Water Quality Standard	Idaho Administrative Code (IDAPA 58.01.02)	Oregon WQ standard	Oregon Administrative Rule
Turbidity (Sediment)	Less than 50 NTU above background for any given sample **OR** Less than 25 NTU for more than ten consecutive days (below any applicable mixing zone set by the IDEQ) applies to waters designated for cold water aquatic life	250.02.d	Less than a 10% cumulative increase in natural stream turbidities	340-41-725, 765, 805, 845 (2)(c)
Sediment	Sediment shall not exceed quantities specified in general surface water quality criteria (IDAPA 58.01.02.250 or 252), or, in the absence of specific sediment criteria, quantities that impair designated beneficial uses.	200.08		
Total Dissolved Gases	Less than 110%, with the authority to specify the applicability of this standard with respect to excess stream flow conditions.	250.01.b 300.01.a	Less than 110%, except when stream flow exceeds the ten-year, seven-day average flood flow	340-41-725, 765, 805, 845 (2)(n)

Table 2.2.2 Water quality targets specific to the Snake River - Hells Canyon TMDL.

Parameter	Selected Target	Where Applied
Bacteria	Less than 126 *E coli* organisms per 100 ml as a 30 day log mean with a minimum of 5 samples AND no sample greater than 406 *E coli* organisms per 100 ml	Full SR-HC TMDL reach (RM 409 to 188)
Dissolved Oxygen (DO)		
• Cold water aquatic life and salmonid rearing	8 mg/L water column dissolved oxygen as an absolute minimum, OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 8 mg/L) dissolved oxygen levels shall not be less than 90%; unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	Downstream Snake River Segment (RM 247 to 188)
• Salmonid spawning, when and where it occurs	11 mg/L water column dissolved oxygen as an absolute minimum OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95%; with intergravel dissolved oxygen not lower than 8 mg/L, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards. These targets will apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188), from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.	Downstream Snake River Segment (RM 247 to 188) October 23 to April 15
• Cool water aquatic life	6.5 mg/L water column as an absolute minimum, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.	Full SR-HC TMDL reach (RM 409 to 188)
Mercury (Hg)	Less than 0.012 ug/L water column concentration (total) Less than 0.35 mg/kg in fish tissue	Full SR-HC TMDL reach (RM 409 to 188)
Nuisance Algae	14 ug/L mean growing season limit (nuisance threshold of 30 ug/L with exceedence threshold of no greater than 25%)	Full SR-HC TMDL reach (RM 409 to 188)
Nutrients	Less than or equal to 0.07 mg/L total phosphorus	Full SR-HC TMDL reach (RM 409 to 188) May through September
Pesticides	Less than 0.024 ng/L water column concentration DDT Less than 0.83 ng/L water column concentration DDD Less than 0.59 ng/L water column concentration DDE Less than 0.07 ng/L water column concentration Dieldrin	Oxbow Reservoir Segment (RM 285 to 272.5) and upstream waters
pH	7 to 9 pH units	Full SR-HC TMDL reach (RM 409 to 188)
Sediment (Turbidity)	Less than or equal to 80 mg TSS/L for acute events lasting no more than 14 days, and less than or equal to 50 mg TSS/L monthly average	Full SR-HC TMDL reach (RM 409 to 188)

Parameter	Selected Target	Where Applied
Temperature • Cold water aquatic life and salmonid rearing	17.8 °C (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 °C. If and when the site potential is greater than 17.8 °C, the target is no more than a 0.14 °C increase from anthropogenic sources. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 °C increase from anthropogenic sources.	Full SR-HC TMDL reach (RM 409 to 188)
• Salmonid spawning, when and where it occurs for specific species	A maximum weekly maximum temperature of 13 °C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 °C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 °C, the target is no more than a 0.14 °C increase from anthropogenic sources. When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 °C increase from anthropogenic sources. These targets will apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188), from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish.	Downstream Snake River Segment (RM 247 to 188) October 23 to April 15
Total Dissolved Gases	Less than 110%, except when stream flow exceeds the ten-year, seven-day average flood flow	Oxbow Reservoir to the Salmon River Inflow (RM 285 to 188)

These targets were established through an evaluation of the stringency of Oregon and Idaho State standards. The methodology and results of this evaluation are described in complete detail in Appendix C.

2.2.2 Overview of Designated Beneficial Uses

Designated surface water beneficial use classifications are intended to protect the various uses of each state's surface water. The specific designated beneficial uses for the SR-HC TMDL reach differ slightly between the two states but the basic concepts are consistent. The various designated beneficial uses can be grouped into five categories: **aquatic life**, **recreation**, **water supply**, **wildlife habitat** and **aesthetics**.

2.2.2.1 General Information

Within Idaho, IDEQ designates beneficial uses for selected waterbodies as outlined in IDAPA 58.01.02.140. Undesignated waterbodies are presumed to support cold water aquatic life and primary or secondary contact recreation unless IDEQ determines that other uses are appropriate. Within Oregon, ODEQ designates beneficial uses for selected waterbodies by basin as outlined in OAR 340-41. Under the Clean Water Act, any uses that existed or were presumed to exist in a waterbody on or after November 28, 1975 are required to be protected as existing uses. The designation of existing uses for protection generally applies to segments where beneficial uses are not formally designated. All of the existing uses in the SR-HC TMDL reach are listed as designated beneficial uses by the states of Oregon and/or Idaho (Table 2.2.3 a and b).

Table 2.2.3 a Idaho segment-specific listings for the Snake River - Hells Canyon TMDL reach.

Segment	Idaho 303(d) Listed Pollutants	Idaho Designated Beneficial Uses
Snake River: RM 409 to 396.4 Upstream Snake River (OR/ID border to Boise River Inflow)	(downstream from ID border) bacteria, dissolved oxygen, nutrients, pH, sediment	(downstream from ID border) cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 396.4 to 351.6 Upstream Snake River (Boise River Inflow to Weiser River Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 351.6 to 347 Upstream Snake River (Weiser River Inflow to Scott Creek Inflow)	bacteria, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply
Snake River: RM 347 to 285 Brownlee Reservoir (Scott Creek to Brownlee Dam)	dissolved oxygen, mercury, nutrients, pH, sediment	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 285 to 272.5 Oxbow Reservoir	nutrients, sediment, pesticides,	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 272.5 to 247 Hells Canyon Reservoir	not listed	cold water aquatic life primary contact recreation domestic water supply special resource water
Snake River: RM 247 to 188 Downstream Snake River (Hells Canyon Dam to Salmon River Inflow)	temperature	cold water aquatic life salmonid spawning primary contact recreation domestic water supply special resource water

*The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning.

Table 2.2.3 b Oregon segment-specific listings for the Snake River - Hells Canyon TMDL reach.

Segment	Oregon 303(d) Listed Pollutants	Oregon Designated Beneficial Uses
Snake River: RM 409 to 395 Upstream Snake River (Owyhee Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics
Snake River: RM 395 to 335 Upstream Snake River to Farewell Bend (Malheur Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (trout) resident fish (warm water) and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics
Snake River: RM 335 to 260 Brownlee Reservoir Oxbow Reservoir Upper half of Hells Canyon Reservoir (Powder Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics hydropower
Snake River: RM 260 to 188 Lower half of Hells Canyon Reservoir Downstream Snake River (Grande Ronde Basin)	Mercury, temperature	public/private domestic water supply industrial water supply irrigation water, livestock watering salmonid rearing and spawning* (downstream) resident fish and aquatic life water contact recreation wildlife and hunting fishing, boating, aesthetics anadromous fish passage commercial navigation and transport

* The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning. Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality criteria apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific criteria for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning.

2.2.2.2 DESCRIPTIONS OF DESIGNATED USES

Aquatic life

Aquatic life classifications are for waterbodies that are suitable or are intended to be made suitable for protection and maintenance of viable aquatic life communities of aquatic organisms and populations of significant aquatic species. Aquatic life uses include the following official Oregon and/or Idaho designated beneficial uses:

- cold water aquatic life
- salmonid rearing and spawning

- resident fish and aquatic life (including warm and cool water designations where applicable)
- anadromous fish passage

Cold Water Aquatic Life (RM 409 to 188).
Waters designated for cold water aquatic life use within the SR-HC TMDL reach are required to exhibit appropriate levels of dissolved oxygen, temperature, pH, ammonia and turbidity for cold water aquatic life support.

Salmonid Rearing and Spawning.
Waters designated for salmonid spawning and rearing within the SR-HC TMDL reach are required to exhibit appropriate levels of water column dissolved oxygen, intergravel dissolved oxygen, temperature, pH, ammonia, toxics, and turbidity for full support of fish during the spawning, incubation and rearing periods for those salmonid species inhabiting the designated waters.

The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning. General time periods identified for spawning and incubation of the salmonid species that occur in these waters are listed below.

Where specific local information is available on actual spawning and incubation periods, this information has been used. The spawning and incubation times referenced in this document are based on site-specific data, laboratory data, and/or literature references as available. If additional site-specific data on spawning and incubation times or water temperatures become available following the submission and approval of this TMDL, these data will be evaluated in the context of the iterative TMDL process. If it is determined that the additional data are appropriate to this TMDL, the time frames and/or temperatures identified for spawning and incubation will be updated as necessary to reflect the expanded data set and improved understanding of the SR-HC TMDL reach and related habitat and use-support needs.

Tributary Spawners:	
Chinook salmon	August 01 to April 01 (spring)
Chinook salmon	August 15 to June 15 (summer)
Rainbow/Steelhead	March 01 to July 15*
Redband trout	March 01 to July 15
Upper Tributary Spawners:	
Bull Trout	September 01 to April 01
Mainstem Spawners:	
Chinook salmon (fall)	October 23 to April 15*
Mountain Whitefish	November 01 to March 30*

* represents spawning times identified by IDFG and ODFW as specific to the SR-HC TMDL reach.

The entire SR-HC TMDL reach (from RM 409 to RM 188) is listed for temperature on the state 303(d) lists. The water quality standards and guidance values identified for temperature in the

SR-HC TMDL are numeric criteria specific to the designated beneficial uses of *cold water aquatic life* and *salmonid spawning and rearing*.

The entire SR-HC TMDL reach (from RM 409 to RM 188) has been designated for cold water aquatic life by the State of Idaho. This same reach has been designated for salmonid spawning and rearing by the State of Oregon. Within the beneficial use designation of salmonid spawning and rearing, the State of Oregon can differentiate between those areas where salmonid spawning occurs and those areas where salmonid rearing occurs separately within a watershed. The water quality targets applied to these areas are then determined by this localized designation of use with salmonid rearing targets applied to those areas designated for salmonid rearing and salmonid spawning targets applied to those areas designated for salmonid rearing.

Specific designation of the salmonid spawning and salmonid rearing beneficial uses are as in the SR-HC TMDL reach follows:

<u>Salmonid Spawning (RM 247 to 188).</u>
The states of Oregon and Idaho have designated the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL reach for salmonid spawning. The designation of salmonid spawning for both Idaho and Oregon specifies that this designation applies only when and where salmonids are present and spawning. As the mainstem Snake River between RM 247 and 188 is an interstate waterway, the more stringent of the two states' standards identified has been identified as the salmonid spawning target for this TMDL (Table 2.2.2).

The State of Idaho and the State of Oregon have designated some of the tributaries to the SR-HC TMDL reach for salmonid spawning based on the available data and the current level of understanding of fish species present. Salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Salmonid spawning is not observed to occur in the Upstream Snake River segment (RM 409 to 335) or the reservoir segments (RM 335 to 247). Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will be determined by each State outside the scope of this TMDL.

This localized designation of salmonid spawning areas is integral to the approach outlined in the initial sections of this document regarding the open acknowledgement by this TMDL effort that there are distinct spatial and temporal use patterns within the specific segments designated for specific beneficial uses within the SR-HC TMDL reach. Targets have been set to recognize those spatial/temporal use patterns that exist, as well as the needed connectivity within the mosaic of designated beneficial uses (including critical habitat for sensitive species) throughout the waterbody; and to provide for full support of existing uses and the restoration of impaired designated uses within that mosaic. In setting specific salmonid rearing and salmonid spawning designations, the SR-HC TMDL also recognizes that this ecosystem is comprised of a variety of aquatic environments that include lentic (still water), lotic (moving water) and transition areas, each with their own characteristic attributes, habitat types and beneficial uses. In this way the proposed approach will result in a TMDL that is achievable, that will meet criteria, and that will support designated beneficial uses without imposing inappropriate and unreachable water quality targets and implementation expectations.

The State of Idaho designation of salmonid spawning as a beneficial use for Brownlee Reservoir, Oxbow Reservoir and Hells Canyon Reservoir has been formally removed by state legislative action finalized on March 30, 2001. For the purposes of this TMDL, the current use designations identified by the states will be applied.

Salmonid Rearing (RM 409 to 188).
The State of Oregon has designated the mainstem Snake River in the SR-HC TMDL reach for salmonid rearing (the State of Idaho equivalent to salmonid rearing is cold water aquatic life). The State of Idaho has designated the entire reach for cold water aquatic life. The salmonid rearing/cold water aquatic life beneficial use designation, and the accompanying water quality targets apply to the mainstem Snake River within the SR-HC TMDL reach. As the mainstem SR-HC TMDL reach of the Snake River is an interstate waterway, the more stringent of the two states' standards identified has been identified as the salmonid rearing/cold water aquatic life target for this TMDL (Table 2.2.2).

Resident Fish and Aquatic Life (RM 409 to 188).
Waters designated for resident fish and aquatic life within the SR-HC TMDL reach are required to exhibit appropriate levels of water column dissolved oxygen, temperature, pH, ammonia and turbidity for full support of fish during the spawning, incubation and rearing periods for those resident species inhabiting the designated waters. In addition to water quality, water level fluctuations can affect fish spawning success. The critical time for nesting by such resident fish as small mouth bass and crappie is from May 1 to June 30. Fluctuating water levels can decrease the amount of suitable spawning, early emergence and early rearing habitat for resident fish.

Anadromous Fish Passage (RM 260 to 188).
It should be noted that although anadromous fish passage is a designated beneficial use above Hells Canyon Dam (RM 247) by the State of Oregon, the only fish passage at Hells Canyon Dam is provided via a trapping system at the dam for collection of anadromous fish for hatchery stocks and upstream "put and take" fisheries. Anadromous Fish Passage is usually intended for passage of both hatchery and wild stock and this is not the case at Hells Canyon Dam. This barrier to fish passage was in place when this beneficial use was designated for the mainstem of the Snake River within the Grande Ronde basin. It seems likely that the designated beneficial use was meant to be applicable only up to the dam and an administrative oversight left it in place up to RM 260. On the other hand, the original Federal Energy Regulatory Commission (FERC) license for the Hells Canyon Dam included anadromous fish passage. So anadromous fish passage could be interpreted as an existing use in 1975. This issue needs to be clarified through an Oregon administrative review of the designated uses for this section of the Snake River. Any proposed change to this designated use would have to be approved by the Oregon Environmental Quality Commission and then approved by US EPA.

The variety of aquatic life that occurs in the SR-HC TMDL reach poses some unique challenges to this TMDL. The most sensitive beneficial uses, often salmonid spawning and rearing, must be protected. There are areas in the SR-HC TMDL reach where salmonid spawning would be quite limited spatially and temporally. For instance, salmonids (with the exception of mountain whitefish (Northcote and Ennis, 1994)) are redd spawners that spawn in areas with moving water and a gravel substrate (Scott and Crossman, 1973). Therefore, salmonid spawning within these drainage basins is most likely to occur within the tributaries to the SR-HC TMDL reach where flow and substrate conditions are favorable to support such uses. Therefore, the salmonid spawning beneficial use designation and its accompanying water quality targets will apply to those tributaries so designated. As these tributaries are not interstate waters, and salmonid spawning use support is a localized habitat issue, state-specific targets for salmonid spawning will apply to those areas of the tributaries designated for salmonid spawning. Therefore, while it is critical to protect spawning habitat in the tributaries, it is not assumed to occur in the mainstem channel of the Upstream Snake River (RM 409 to 335) and reservoir segments (RM 335 to 247).

In addition, the resident (non-salmonid) fish make up the dominant community in the reservoirs as these species are most suited to the physical conditions that are present in reservoir and lake systems, and naturally inhabit reservoirs and lakes. The salmonids that use these reservoirs are rainbow trout and mountain whitefish. Therefore, it is important to protect the water quality and habitat of the resident fish in the reservoir and free-flowing areas, as well as maintaining sufficient quality where appropriate in the reservoirs for the limited salmonid populations. As a result of the complexity of the aquatic life in the SR-HC TMDL reach, this TMDL depends on spatial and temporal analysis of needs of the dominant fish communities in establishing targets and loads while maintaining sufficient areas of appropriate water quality to protect the non-dominant species.

Recreation

Recreation classifications are for waterbodies that are suitable or are intended to be made suitable for primary and secondary contact recreation; this includes fishing for consumption. Water or primary contact recreation refers to prolonged and intimate human contact with water where ingestion is likely to occur, such as swimming, water skiing and skin diving. Secondary contact recreation refers to uses where intimate human contact and ingestion of water is expected to occur to a lesser degree such as fishing, boating and wading. Recreation uses include the following official Oregon and/or Idaho designated beneficial uses:

- water contact recreation (including primary contact recreation)
- fishing
- boating

Water Contact Recreation (RM 409 to 188).

The SR-HC TMDL reach is designated for both primary contact recreation and water contact recreation. These classifications are for waterbodies that are suitable or intended to be made suitable for prolonged and intimate human contact with water where ingestion is likely to occur, such as swimming, water skiing and skin diving. Therefore, designated waters are required to meet surface water quality criteria specific for bacteria and nuisance algal growth.

Fishing (RM 409 to 188).

Waters with this designation within the SR-HC TMDL reach are required to meet all criteria for the support of fishing as contained in the general surface water quality criteria of Oregon and Idaho. In addition to meeting the criteria described above for the protection of fish, these waters must also meet criteria for both states regarding nuisance algal growth and toxic materials that may affect such uses as fishing for human consumption.

Boating (RM 409 to 188).
Waters with this designation within the SR-HC TMDL reach are required to meet all criteria for the support of boating particularly those for bacteria and nuisance algal growth.

Water Supply
Water supply classifications are for waterbodies that are suitable or are intended to be made suitable for agriculture, domestic and industrial uses. Industrial water supply includes hydropower uses where designated. Water supply uses include the following official Oregon and/or Idaho designated beneficial uses:

- public/private domestic water supply
- agricultural water supply (including irrigation water and livestock watering)
- industrial water supply
- hydropower generation
- commercial navigation and transportation

Public/Private Domestic Water Supply (RM 409 to 188).
Waters designated for domestic water supply within the SR-HC TMDL reach are required to meet general surface water quality standards for toxic materials and turbidity. These waters, while not required to meet drinking water standards in-stream, must be of sufficient quality that it is possible for them to meet drinking water standards with conventional treatment measures.

Agricultural Water Supply (RM 409 to 188).
Waters designated as agricultural water supply (including irrigation water and livestock watering) within the SR-HC TMDL reach are required to be suitable for the irrigation of crops or as drinking water for livestock. Waters designated for agricultural water supply are required to meet general surface water quality criteria for toxic materials. These waters are also required to meet narrative criteria related to sediment and excessive nutrients.

Industrial Water Supply (RM 409 to 188).
Waters designated as industrial water supply are required to be suitable for industrial uses. Waters designated for industrial water supply within the SR-HC TMDL reach are required to meet general surface water quality criteria.

Hydropower Generation (RM 335 to 260).
No hydropower facilities are located in the Upstream (RM 409 to RM 335) or Downstream (RM 247 below Hells Canyon Dam to RM 188) Snake River segments of the SR-HC TMDL reach (see Section 2.3 for a more detailed discussion of these segments) but the flows into the SR-HC TMDL reach are regulated by upstream and tributary hydropower and irrigation developments. Brownlee, Oxbow, and Hells Canyon Dams are located within the SR-HC TMDL reach and are operated for hydropower generation. These three facilities are collectively referred to as the Hells Canyon Complex (HCC).

Brownlee Reservoir was constructed primarily for power production although it is also operated for flood control purposes through direction from the US Army Corps of Engineers. The reservoir is also currently operated with consideration for anadromous fish protection and passage in the downstream reaches of the Snake and Columbia rivers under consultation with NMFS. Brownlee Reservoir provides the flows from the Hells Canyon Complex for fish protection and passage. Brownlee Dam was completed in 1958, with a nameplate generating capacity of 585.4 megawatts (MW). (Nameplate capacity is the capacity of a facility based on output at maximum efficiency.)

Oxbow Reservoir was constructed and is currently operated for power production. Oxbow Dam was completed in 1961 with a nameplate generating capacity of 190 MW.

Hells Canyon Reservoir was constructed and is currently operated for power production. Hells Canyon Dam was completed in 1969 with a nameplate generating capacity of 391.5 MW. It should be noted that although hydropower generation is a designated beneficial use extending from Farewell Bend (RM 335) to midway through the Hells Canyon Reservoir above Hells Canyon Dam (RM 260) by the State of Oregon, it is recognized that hydropower generation occurs at the Hells Canyon Dam (RM 247). The dam was in place and operating when this beneficial use was designated for the mainstem of the Snake River. Thus hydropower at Hells Canyon Dam was an existing use in 1975. Therefore the designated beneficial use of hydropower was most probably meant to be applicable downstream to the dam but not beyond. This is the interpretation that will be used in this document; however, this is an issue that should be resolved by an administrative review of the Oregon designated uses in this section of the Snake River. Any proposed change to this designated use would have to be approved by the Oregon Environmental Quality Commission and then approved by US EPA.

Many factors can affect the operation of hydropower facilities. Changes in operation efficiency, reservoir release flow and reservoir water surface elevation can affect the amount of energy produced. The energy production of run-of-the-river hydropower facilities (like the HCC) can change if the stream flows change. Inflowing tributaries to the SR-HC TMDL reach can therefore affect hydropower generation within the mainstem reservoirs. Operation of these facilities can in turn affect water levels and flow characteristics downstream and can impact hydropower generation at downstream facilities. Changes in diversions to irrigation canals can also affect generation at hydropower facilities located downstream. Water quality of water flowing into a hydropower reservoir can also substantially affect the operation and efficiency of power production. If inflowing water is degraded, operational alterations, physical modifications, or in-reservoir water quality improvements may be required so that project discharges and water within the reservoir are not substandard. These requirements can significantly affect the ability of the project to operate efficiently and meet power needs. TMDLs are required for waters that do not meet state standards. Operation of hydropower facilities under the FERC licensing process must provide consideration for both power generation and the environment. Additionally, one of the primary influences on the operation of hydropower facilities is consumer and system demand. Consumer demand can influence flow from hour to hour during any day.

The operation of hydroelectric power generation facilities within the Pacific Northwest is accomplished through a grid of private, non-federal public and federal transmission lines. Electricity is transferred throughout this grid system to those locations where it is needed regardless of ownership of power lines and generating facilities. Because of the interconnection of the power grid, any large change anywhere in the system may be felt throughout the system (USBR, 1998).

Commercial Navigation and Transportation (RM 260 to 188).
It should be noted that although commercial navigation and transportation is a designated beneficial use above Hells Canyon Dam by the State of Oregon, commercial navigation and transportation through the dam is not possible as there are not any shipping locks at the dam. In addition, this designation only goes halfway up Hells Canyon Reservoir (RM 260) but no further, suggesting it is not meant for small chartered commercial craft. However, this barrier to navigation and transportation was in place when this beneficial use was designated for the mainstem of the Snake River within the Grande Ronde basin. Therefore, the designated beneficial use was most probably meant to be applicable up to the dam but not beyond. This is the interpretation that will be used in this document. However this is an issue that should be resolved by an administrative review of the Oregon designated uses in this section of the Snake River. Any proposed change to this designated use would have to be approved by the Oregon Environmental Quality Commission and then approved by US EPA.

Wildlife habitat
Wildlife habitat waters are those which are suitable or are intended to be made suitable for wildlife habitat and hunting and are represented by the official Oregon designated beneficial use of:

- wildlife and hunting

Wildlife and Hunting (RM 409 to 188).
This designated beneficial use is applied to water bodies utilized by various non-game wildlife species in addition to game species and hunters. Waters with this designation within the SR-HC TMDL reach are required to meet all criteria for the support of wildlife habitat as contained in the general surface water quality criteria of Oregon and Idaho.

Aesthetics
Aesthetics are designated as a beneficial use for special resource waters or for aesthetic enjoyment of a waterway. Special resource waters are those waters protected due to unique or outstanding characteristics or where intensive protection of the water quality is necessary to maintain an existing but jeopardized designated beneficial use. Aesthetic uses include the following official Oregon and/or Idaho designated beneficial uses:

- aesthetics
- special resource waters

Aesthetics (RM 409 to 188).
This use includes those waters within the SR-HC TMDL reach protected due to unique or outstanding aesthetics characteristics or where intensive protection of the water quality is necessary to maintain aesthetic enjoyment.

Special Resource Waters (RM 409 to 188).
This use includes those waters within the SR-HC TMDL reach protected due to unique or outstanding characteristics or where intensive protection of the water quality is necessary to maintain an existing but jeopardized designated beneficial use.

2.2.2.3 THREATENED AND ENDANGERED SPECIES

The SR-HC TMDL reach provides habitat for the Idaho spring snail (identified in the region between RM 422 and 393 and between RM 372 and 340) and the Bliss Rapids snail (identified in the region between RM 228 and 225 and in several areas of the Snake River upstream of the SR-HC TMDL reach). Both of these snail species are listed as threatened under the Federal ESA, both are listed as requiring cold, clear, well oxygenated water for full support.

Adult bull trout, known to utilize the reservoir segments (RM 335 to 247), are listed as threatened under the ESA. The SR-HC TMDL reach and some inflowing tributaries below Hells Canyon Dam (RM 247) also provide habitat for the Snake River fall and spring/summer chinook as well as steelhead, all of which are listed as threatened under the ESA. In addition, pacific lamprey are rumored to inhabit the river below Hells Canyon Dam, however, no sampling effort has identified them in any quantity, and no available published reports refer to their presence currently.

Idaho Springsnail (*Pyrgulopsis idahoensis,* formerly *Fontelicella idahoensis* (Frest and Johannes, 2001))
Status: Endangered (57 FR 59257, December 14, 1992)
Distribution: Random locations at sites near CJ Strike Reservoir, Upstream to Bancroft Springs. Recent population studies have identified Idaho Springsnails in the mainstem Snake River from RM 422 to 393 and from RM 372 to 340 (IPCo, 2001a).
Habitat requirements: Free flowing, clear, cold water environments
Reasons for status: Loss of habitat due to alteration of natural flows and declining water quality.
Solutions: Prevention of further Snake River diversions, improved water quality and natural flow corridors.
Information provided by: US Fish and Wildlife Service

Bliss Rapids snail (*Taylorconcha serpenticola*)
Status: Threatened (57 FR 59257, December 14, 1992)
Distribution: Random locations at sites between Salmon Falls and King Hill. Recent population studies have identified Bliss Rapids snails in the mainstem Snake River below Hells Canyon Dam from RM 229 to 225 (IPCo, 2001a).
Habitat requirements: Gravel and boulders of swift currents, usually just below canyon segments in the river, in rapids or in boulder bars just below rapids. Free flowing, clear, cold water environments.
Reasons for status: Loss of habitat due to alteration of natural flows and declining water quality.
Solutions: Prevention of further Snake River diversions, improved water quality and natural flow corridors.
Information provided by: US Fish and Wildlife Service

Bull Trout (*Salvelinus confluentus*)
Status: Threatened (Conterminous US, 64 FR 58910, November 1, 1999)
Distribution: Adult Bull trout identified in the Hells Canyon Reservoir and Downstream Snake River segments of the SR-HC TMDL reach (mainstem Snake River from RM 272.5 to RM 188). Bull trout have been identified to spawn in the upper reaches of some tributaries to the SR-HC

TMDL reach. Spawning is not identified to occur in the mainstem Snake River within the TMDL reach.
Habitat requirements: Free flowing, cold-water environments
Reasons for status: Loss of habitat, degraded habitat, declining water quality, increased sedimentation in spawning gravels, higher stream temperatures, blocked migratory corridors and introduction of competing, non-native fish species.
Solutions: Restricted fishing, prohibited non-native species introduction, protection of habitat, public education for proper identification.
Information provided by: US Fish and Wildlife Service and Idaho Department of Environmental Quality

Fall Chinook (*Oncorhynchus tshawytscha*)
Status: Threatened (58 FR 49880, September 23, 1993, Critical Habitat Designated 59 FR 54840, November 2, 1994)
Distribution: Mainstem Snake River from RM 247 to RM 188.
Habitat requirements: Free flowing, cold water environments with appropriate spawning gravels.
Reasons for status: Habitat loss and degradation, declining water quality, mistaken angler harvest, impoundments (low seaward migration survival) and blocked migratory routes.
Solutions: Improved seaward migration survival, habitat restoration, reduced harvest and improved water quality.
Information provided by: National Marine Fisheries Service

Spring and Summer Chinook (*Oncorhynchus tshawytscha*)
Status: Threatened (58 FR 49880, September 23, 1993, Critical Habitat Designated 59 FR 54840, November 2, 1994)
Distribution: Mainstem Snake River from RM 247 to RM 188.
Habitat requirements: Free flowing, cold water environments with appropriate spawning gravels.
Reasons for status: Habitat loss and degradation, declining water quality, mistaken angler harvest, impoundments (low seaward migration survival) and blocked migratory routes.
Solutions: Improved seaward migration survival, habitat restoration, reduced harvest and improved water quality.
Information provided by: National Marine Fisheries Service

Steelhead (*Oncorhynchus mykiss*)
Status: Threatened (63 FR 32997, June 17, 1998; Critical Habitat Designated 59 FR 54840, November 2, 1994)
Distribution: Mainstem Snake River from RM 247 to RM 188.
Habitat requirements: Free flowing, cold-water environments
Reasons for status: Loss of habitat, degraded habitat, declining water quality, increased sedimentation in spawning gravels, higher stream temperatures, blocked migratory corridors and overfishing.
Solutions: Improved seaward migration survival, habitat restoration, reduced harvest, restoration of natural flows and improved water quality.
Information provided by: National Marine Fisheries Service

Bald Eagle (*Haliaeetus leucocephalus*)
Status: Threatened (60 FR 36010, July 12, 1995; Proposal to delist, 64 FR 36453, July 6, 1999)
Distribution: Throughout the SR-HC TMDL reach, RM 409 to 188.
Habitat requirements: Bald eagles use snags, trees with exposed limbs and lateral branches, for perching and nesting. Forage is predominantly fish and small birds.
Reasons for status: Lack of adequate perch trees, recreational and urban encroachment on nesting and forage territories, poor water quality, low reproductive success and direct bird mortality due to DDT, lead poisoning due to feeding on waterfowl containing lead shot.
Solutions: Ban on DDT in 1972, phasing out of lead shot, protection of nesting areas, wintering areas and food sources.
Information provided by: US Fish and Wildlife Service and Idaho Department of Fish and Game

2.2.2.4 Other Use Refinement Processes

An effort is currently in progress within the Lower Snake River Basin to assess the existing beneficial use designations for applicability and attainability. This effort has been undertaken by stakeholders of both the Lower Boise River TMDL and the SR-HC TMDL processes. These stakeholders and their technical advisors are conducting an in-depth study of the current use designations, the actual uses existing today, and the attainability of current use designations. Initial discussions of the potential outcomes of the current use refinement effort follow closely with the findings and recommendations of the SR-HC TMDL.

The information produced by this and any other similar efforts will be evaluated within the context of the SR-HC TMDL process. The data collected and the conclusions drawn will be reviewed by the DEQs. If changes to the current designated beneficial uses are determined to be appropriate, state-specific processes will be initiated to make changes to the use designations. Changes to the SR-HC TMDL, if appropriate, will be made. As these use refinement studies will most likely not be completed until after the submission of the SR-HC TMDL, changes (if appropriate) will be incorporated during the phased implementation process.

2.2.3 Water Quality Limited Waters

Under section 303(d) of the CWA, waters that do not meet water quality standards even with the implementation of technology-based effluent limits (40 CFR 130.7(b)) are listed as water quality limited waters. These waters are required to have a TMDL developed to bring them back into compliance with water quality standards. The mainstem Snake River, from where the river intersects the Oregon/Idaho border at RM 409 downstream to immediately above the inflow of the Salmon River at RM 188 has been identified as water quality limited, due to violations of water quality standards for both Oregon and Idaho. Tables 2.2.3 a and b give a complete listing of all designated beneficial uses and pollutant listings for each segment within the scope of the TMDL for the two states. A further discussion of the designated beneficial uses, pollutant listings, available data and evidence of non-compliance with standards is contained in the following sections on each segment of the SR-HC TMDL reach (Section 2.3). To delineate between current and previous data collection efforts the terms *historical data* and *current data* are used. For the purposes of this document, historical data is defined as data collected prior to 1975. Current data is defined as data collected during or after 1975.

2.2.4 General Water Quality Concerns for the Snake River - Hells Canyon TMDL Reach

Some common water quality issues occur in more than one segment of the SR-HC TMDL reach. The following sections will outline these general issues by pollutant parameter. More detailed and individually relevant discussions will be offered under the discussion of each individual segment (Section 2.3). Those pollutants that only appear in a single segment are presented in the section for that individual segment. Discussion of general concerns below and in the segment specific sections that follow is not meant to indicate that all potential effects discussed in these sections occur within the SR-HC TMDL reach. Rather, it is intended as a general overview of potential effects from the pollutants listed for this system. A range of potential effects from relatively minor to more severe are discussed for most pollutants. This is intended as general information only and is not intended to imply that the full range of possible effects is currently occurring, or has ever occurred within the SR-HC TMDL reach.

2.2.4.1 Dissolved Oxygen

General Concerns

Dissolved oxygen (DO) is important to the health and viability of fish and other aquatic life. High concentrations of dissolved oxygen (from 6 to 8 mg/L or greater) are beneficial to aquatic life. Low dissolved oxygen (concentrations below 5 mg/L) can result in stress to aquatic species, lower resistance to environmental stressors and even death at very low levels (less than 2 mg/L). Intergravel dissolved oxygen levels of 5 to 6 mg/L or more are needed to support salmonid spawning and water column dissolved oxygen needs to be 6 to 11 mg/L or more during spawning and at locations where spawning is designated to occur within the SR-HC TMDL reach.

In addition to the above direct effects on aquatic life, low dissolved oxygen concentrations can lead to changes in water and sediment chemistry that can influence the concentration and mobility of nutrients and toxins, e.g. phosphorus, ammonia and mercury, in the water column. Low dissolved oxygen at the sediment-water interface can result in substantial releases of adsorbed phosphorus to the water column, which in turn can lead to increased algal growth and further decrease the dissolved oxygen concentration in a waterbody. Anoxic conditions, combined with available organic matter can also result in higher rates of methyl-mercury production. Methyl-mercury represents a significantly greater threat for bioconcentration and accumulation than elemental or mineralized mercury compounds. Finally, increased water column ammonia concentrations can result from the chemical changes caused by anoxic conditions. Elevated ammonia levels can represent a significant threat to the health of aquatic life forms, and, at extreme concentrations, can result in death.

Water Quality Targets

In order to meet the water quality criteria of both states, a target of 6.5 mg/L water column dissolved oxygen has been established by this TMDL as an absolute minimum to ensure full support of cool water and cold water aquatic life. This target applies to the Snake River between RM 409 and 335, Brownlee Reservoir (RM 335 to 285), and Oxbow Reservoir (RM 285 to 272.5) as the designated uses for both states reflect cool and cold water aquatic life as the most sensitive overall population. Because of the dominance of cool water fish in the reservoirs (Brownlee and Oxbow) and in the Upstream Snake River (RM 409 to RM 335) (ODFW, 2001), the cool water aquatic life dissolved oxygen standard for the State of Oregon (6.5 mg dissolved oxygen/L) was used as the basis for the dissolved oxygen target for interstate waters in these segments of the SR-HC TMDL. Both the cool water and the cold water dissolved oxygen standards for the State of Oregon were determined to be more stringent than the cold water standard for the State of Idaho. Therefore, it was determined that basing the SR-HC TMDL dissolved oxygen target on the Oregon water quality criteria for cold water aquatic life would result in a dissolved oxygen target that was more conservative than necessary for these interstate segments of the Snake River based on the dominant fish populations. As a result, where cool water aquatic life are the dominant community rather than cold water aquatic life, an absolute minimum target is 6.5 mg dissolved oxygen/L, while 8.0 mg dissolved oxygen/L is the absolute minimum where cold water aquatic life are the dominant community (Downstream Snake River segment (RM 247 to 188)). These targets are based on dissolved oxygen concentrations in the critical aquatic environment. Most natural, unpolluted waters will have sufficient dissolved oxygen to meet these targets.

Salmonid spawning has been designated to occur in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL. The dissolved oxygen target for salmonid spawning is 11 mg/L water column dissolved oxygen as an absolute minimum OR (where conditions of barometric pressure, altitude, and temperature preclude attainment of 11 mg/L) dissolved oxygen levels shall not be less than 95 percent saturation; with intergravel dissolved oxygen not lower than 8 mg/L, unless adequate, i.e. continuous monitoring, data is collected to allow assessment of the multiple criteria section in the standards.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated dissolved oxygen targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round. The salmonid spawning beneficial use designation and the associated dissolved oxygen targets apply to the mainstem Snake River in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL between October 23 and April 15.

Common Sources

Low dissolved oxygen is often the result of high nutrient, organic or algal loading to a surface water system. Nutrients lead to algal growth, which in turn consumes oxygen from the water column during periods when respiration is the dominant process. In addition, in slow moving streams, and in lakes and reservoirs, when algae die and settle to the bottom of the water body, aerobic decomposition of the dead algae and other detritus (non-living organic material) can also deplete the oxygen supply in the overlying water and sediment. In systems where suspended solids are primarily organic in origin, low dissolved oxygen levels may be correlated with sediment inputs as well.

Dissolved oxygen concentrations are also reduced by pollutants that require oxygen in oxidation processes. Biochemical oxygen demand (BOD) is a measure of the dissolved oxygen required to oxidize material (usually organic) whether it is naturally occurring, the result of increased natural material, or contained in municipal, agricultural, or industrial wastes. Parts of the SR-HC TMDL reach carry a substantial load of such organic material. This organic load is delivered by the inflowing Snake River above the TMDL reach, by the inflowing tributaries, and by organic matter production within the reach. Some of this organic material is algae and some is detritus. Both of these organic matter components produce a certain amount of BOD.

2.2.4.2 MERCURY

The SR-HC TMDL reach is listed as water quality limited due to human fish consumption advisories for mercury issued by both Oregon and Idaho (Appendix D). Elevated levels of mercury in fish tissues have been observed in both the Upstream Snake River (RM 409 to 335) and Brownlee Reservoir (RM 335 to 285) segments of the SR-HC TMDL reach (Rinella *et al.*, 1994; Clark and Maret, 1998). In addition, data have shown a similar problem in the Owyhee basin (Rinella *et al.*, 1994; Craft *et al.*, 2000). Because of the fish consumption advisories in place, the designated beneficial use of fishing for both Oregon and Idaho is not fully supported.

General Concerns

The presence of mercury in surface waters can be a water quality concern, especially when present in readily mobile and easily accumulated forms such as methylated mercury. In rare cases, when concentrations are extremely high, mercury can result directly in the death of aquatic biota. More commonly, bioaccumulation and concentration affect designated beneficial uses (fishing and wildlife habitat) by building up concentrations within the food chain to levels where consumers (human or other predators) can be adversely affected.

Water Quality Targets

Bioaccumulation of mercury to dangerous levels in fish tissues is the basis for the current human fish consumption advisories within the SR-HC TMDL reach, issued by the states of Oregon and Idaho (Appendix D). Mercury concentrations of concern to the direct health of aquatic life are identified in the US EPA toxics rule and ODEQ Table 20, as cited in Table 2.2.1 of this document. In order to meet the water quality criteria of both states, a target of less than 0.012 ug/L total recoverable water column mercury has been established by this TMDL process as an absolute maximum to support the designated beneficial use of fishing and domestic water supply. It should be noted that this water column target is only one of the factors that determine fish tissue mercury levels. It is the fish tissue mercury levels that determine the necessity for a fish consumption advisory and therefore the lack of full support of fishing as a designated use. In addition, US EPA (2001a, 2001b, 2001c) has recently issued guidance on mercury criteria based on fish tissue levels. The fish tissue mercury concentration identified by this guidance as protective for human health is 0.3 mg/kg wet weight.

The fishing and salmonid rearing/cold water aquatic life beneficial use designation and the associated mercury targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round.

Common Sources

The primary sources of mercury in the SR-HC TMDL reach are air deposition, legacy mining activities and natural geologic materials. Historical agricultural chemicals, industrial and municipal source inputs of mercury are generally considered to be relatively minor within this reach compared to the air deposition, legacy mining and natural geologic inputs. The SR-HC TMDL reach has been the site of a number of mining activities mostly for gold, silver and mercury ores. Gold was mined in the Central Mountain landform particularly in the Blue, Seven Devils and Wallowa Mountains but also along the banks of the Snake River itself. Gold, silver, uranium, bentonite (volcanic ash) and mercury were mined in the Owyhee uplands and Malheur

County. Silver City, Idaho, located in the Jordan valley area of the Owyhee River watershed, was the site of a major silver mining operation. Mercury was used to amalgamate gold and silver at mining sites throughout the region, and is still present in mining tailings and around old mining sites. Much of the mercury used locally for amalgamation of silver and gold was mined just outside the Owyhee watershed (Idaho) in the Opalite mining district near the McDermitt caldera in southeastern Oregon. Most of the mines have not been in routine operation since the 1950s or 1960s but there are occasional, usually small, mining activities currently in place.

2.2.4.3 NUTRIENTS

General Concerns

General concerns associated with excessive nutrient concentrations include both direct and indirect effects. Direct effects are nuisance algae and periphyton growth. Indirect effects include low dissolved oxygen, increased methylmercury production, elevated pH, cyanotoxins from cyanobacteria (blue-green algae) production, trihalomethane production in drinking water systems, and maintenance issues associated with domestic water supplies.

Nuisance aquatic growth, both algae (phytoplankton or water column algae, and periphyton or attached algae) and rooted plants (macrophytes), can adversely affect both aquatic life and recreational water uses. Algal blooms occur where nutrient concentrations (nitrogen and phosphorus) are sufficient to support growth. Available nutrient concentrations, flow-rates, velocities, water temperatures and penetration of sunlight in the water column are all factors that influence algae (and macrophyte) growth. When conditions are appropriate and nutrient concentrations exceed the quantities needed to support algal growth, excessive blooms may develop. Commonly, these blooms appear as extensive layers or algal mats on the surface of the water. When present at excessive concentrations in the water column, cyanobacteria (blue-green algae) often produce toxins that can result in skin irritation to swimmers, and illness or even death in organisms ingesting the water. Two canine deaths due to ingestion of blue-green algal toxins were confirmed (November, 2000) and several others suspected (Fall 1999) below the Minidoka Dam along the Snake River between Rupert and Burley, Idaho (Eyre, 2001). In Cascade Reservoir, located upstream in the Payette River drainage, 23 cattle died from ingestion of cyanotoxins in 1993. Several types of cyanobacteria (blue-green algae) produce cyanotoxins. Most commonly, hepatotoxins (which can affect liver and kidney function) and/or neurotoxins (which can affect central nervous system functions) are produced. While not every bloom produces such toxins, increased levels of growth (greater biomass) are more likely to produce higher concentrations of these compounds.

The US EPA identifies nutrient enrichment as a serious health problem in the context of drinking water supplies. Trihalomethanes are carcinogenic compounds that can be produced when water containing organic compounds is chlorinated or brominated as part of the treatment and disinfection processes in drinking water facilities. The organic compounds commonly associated with trihalomethane formation processes are humic substances, algal metabolites and algal decomposition products (US EPA, 2000d). According to references in the recent US EPA nutrient guidance document for surface waters, the density of algae and the level of eutrophication in the raw water supply have been correlated with the production of trihalomethanes (US EPA, 2000d).

Algal blooms also often create objectionable odors and coloration in water used for domestic drinking water supplies, and can produce intense coloration of both the water and shorelines. In extreme cases algal blooms can also result in impairment of agricultural water supplies due to toxicity. Waterbodies with high nutrient concentrations that could potentially lead to a high level of algal growth are said to be eutrophic. Algae is not always damaging to water quality, however. The extent of the effect is dependent on both the type(s) of algae present and the size, extent and timing of the bloom. In many systems algae provide a critical food source for many aquatic insects, which in turn serve as food for fish.

In addition to the direct effects of excessive algal growth, when algae die, they sink slowly through the water column, eventually collecting on the bottom sediments. The biochemical processes that occur as the algae decompose remove oxygen from the surrounding water. Because most of the decomposition occurs within the lower levels of the water column, dissolved oxygen concentrations near the bottom can be substantially depleted by a large algal bloom. Low dissolved oxygen in these areas can lead to decreased fish habitat and even fish kills if there are not other areas of water with sufficient dissolved oxygen available where the fish can take refuge. Both living and dead (decomposing) algae also can affect the pH of the water due to the release of various acid and base compounds during respiration and photosynthesis. Additionally, low dissolved oxygen levels caused by decomposing organic matter can lead to changes in water chemistry and release of sorbed phosphorus to the water column at the water/sediment interface. These same conditions are conducive to methylmercury production in areas where inorganic mercury is present in the system.

Both nitrogen and phosphorus represent nutrients that can contribute to eutrophication. Either nutrient may be the limiting factor for algal growth depending on algal species. Cyanobacteria (blue-green algae) can dominate in nitrogen-limited systems as they are able to fix nitrogen from the atmosphere (at the air/water interface) and from the water column. In systems where cyanobacteria (blue-green algae) are the dominant population, nitrogen is not a limiting agent based on this ability to fix nitrogen. Therefore, these organisms can grow where low nitrogen concentrations may inhibit the growth of other algal species (Sharpley *et al.*, 1995 and 1984; Tiessen, 1995; IDEQ, 1993b). The dominant algal types observed in the SR-HC system are cyanobacteria (blue-green algae), also known as cyanobacteria, and diatoms, depending on the specific location and season (IPCo, 1998a and 1999d).

Phosphorus can be measured in a variety of ways. The most common forms of phosphorus monitored in the SR-HC TMDL reach are total phosphorus (TP), which includes all phosphorus (dissolved and particulate-bound) in a sample; and ortho-phosphate (OP), which includes highly soluble, oxidized phosphorus. Because of its solubility, ortho-phosphate is commonly more available for biological uptake and leads more rapidly to algal growth than total phosphorus. The relative amount of each form measured can provide information on the potential for algal growth within the system. If a high percentage of the total phosphorus is present as soluble ortho-phosphate, it is more likely that rapid algal growth will occur than if the majority of the total phosphorus was mineral phosphorus incorporated in sediment, provided other conditions such as light and temperature were adequate. Due to phosphorus cycling (conversion between forms) it is important to consider total phosphorus concentrations in the evaluation of nutrient loading.

Excess nutrient loading can be a water quality problem due to the direct effect of high phosphorus concentrations on excess algal growth within the water column, combined with the direct effect of the algal life cycle on dissolved oxygen and pH within aquatic systems. As total phosphorus includes both dissolved and particulate-bound phosphorus, it represents the phosphorus that is currently available for growth as well as that which has the potential to become available over time. Therefore, the reduction of total phosphorus inputs to the system can act as a mechanism for water quality improvements particularly in surface-water systems dominated by cyanobacteria (blue-green algae) which can acquire nitrogen directly from the atmosphere and the water column. Phosphorus management within these systems can potentially result in improvement in the following water quality parameters: nutrients (phosphorus), nuisance algae, dissolved oxygen and pH.

Consideration of flow is important in the evaluation of nutrient and phytoplankton, periphyton, and rooted macrophyte concentrations. In a riverine system, flow transports phytoplankton and nutrients from upstream to downstream in an advective or dispersive transport mode. In other words, the riverine system is a dynamic system in which nutrients are being continually cycled as the water moves downstream. The flow regimen is important in determining the result of this combination of component concentrations. High flows can flush dissolved constituents like nutrients downstream replacing them with the concentrations in the high flows. High flows can also scour periphyton and rooted macrophytes, reducing their concentrations considerably. Finally, high flows can scour sediments causing movement of the sediment downstream and increasing nutrient concentrations at the same time by releasing nutrients tied up in the sediments prior to scouring (Armstrong, 2001).

High total phosphorus concentrations can result in increased algal growth rate and increased productivity up to the saturation point. Increased total phosphorus loading can result in increased algal production and increased algal biomass. The increased algal biomass production and transport results in increased biological oxygen demand (BOD) and decreased dissolved oxygen levels. The reservoir systems in the Snake River, particularly those in the Hells Canyon Complex, modify the river's flow regimen to the extent that the water's residence time in a particular stretch of the river is increased, and the greater the increase the greater the affect on water quality. (Residence time within the Hells Canyon Complex averages approximately 34 days for Brownlee Reservoir, 1.4 days for Oxbow Reservoir and 4 days for Hells Canyon Reservoir, 39.4 days total.) Such an increase residence time is caused by an increase in water volume behind the impoundment due to widening and deepening of the channel. In addition, the deeper the channel the greater the opportunity for thermal (density) stratification. The kinds of physical, chemical, and biological processes that can take place in such systems as Brownlee Reservoir under lower flow conditions are described by IPCo (1999d). However, their description does not represent the changes that occur under higher flow conditions in which the reservoir becomes more riverine in nature (Armstrong, 2001).

A separate consideration is the difference between algae concentrations and the rate of algal growth. Algal concentrations are a function of the availability of nutrients on a continuing basis, the availability of adequate light, and the presence of flows (velocities) that will permit continued growth without losses due to flushing (of phytoplankton), sloughing (of attached algae or periphyton), or mechanical breakage and scouring (of rooted macrophytes). In quiescent systems like lakes, algal concentrations are dependent on nutrient availability, and only if nutrient concentrations have been depleted by algal uptake does the growth rate approach zero, and phytoplankton begin to die. In streams and rivers, the nutrients also cycle between the water, sediment, living organisms, and detritus (nutrient spiraling as it is called), but high velocities generally occur often enough to scour attached and rooted vegetation and to keep concentrations of aquatic vegetation low. Under low velocities, however, attached and rooted vegetation may increase to noticeable levels. As long as nutrients continue to be available and flows are inadequate to cause losses of algae mass, the algae will continue to grow and may reach levels that cause algal mats on the bottom or at the surface. This is often the case in shallow lakes or ponds or pools in intermittent streams. However, the presence of algal mats or attached algae does not necessarily indicate an excess of nutrients (Armstrong, 2001).

Water Quality Targets

Nutrient concerns for both Oregon and Idaho are assessed through the interpretation of narrative criteria based on excessive or nuisance aquatic growth. Numeric targets established to support designated beneficial uses within the SR-HC TMDL reach were based on an understanding of nutrient transport and processing within this system, research carried out in systems with similar climate and geology, and the linkage established between inflowing nutrient concentrations, organic growth and decay and water chemistry processes (affecting dissolved oxygen, pH, nutrient desorption, etc). The Mid-Snake River TMDL (IDEQ, 1997c) established a 0.075 mg/L in-stream phosphorus concentration for support of designated beneficial uses in the reach from RM 638.7 to RM 544.7. Similar targets have been identified by the SR-HC TMDL. A total phosphorus target of less than or equal to 0.07 mg/L has been identified as appropriate to reduce nutrient and organic loading and transport, and as a surrogate target to improve dissolved oxygen concentrations within the SR-HC TMDL reach.

In addition, ODEQ has identified a threshold level of 0.015 mg chlorophyll *a*/L as an indication that further assessment is necessary to determine if nutrient concentrations or algal populations are sufficient to impair beneficial uses. Chlorophyll *a* concentrations of greater than 0.015 mg/L, observed to occur for three months, triggers an investigation by ODEQ to determine if designated uses are being impaired in the particular watershed being monitored. This TMDL serves as the ODEQ investigation into impairment due to observed chlorophyll *a* concentrations above the threshold level in the SR-HC TMDL reach. The chlorophyll *a* target for this TMDL was set at 14 ug/L mean growing season limit (nuisance threshold of 30 ug/L with exceedence threshold of no greater than 25 percent) to be protective of designated beneficial uses. This target is also based on an understanding of nutrient transport and processing within this system, research carried out in systems with similar climate and geology, and the linkage established between inflowing nutrient concentrations, organic growth and decay and water chemistry processes (affecting dissolved oxygen, pH, nutrient desorption, etc).

Therefore, the SR-HC TMDL will use a combination of the 14 ug/L chlorophyll *a* mean growing season limit and the 0.07 mg total phosphorus/L to ensure that nutrient concentrations do not result in excessive algae or other aquatic growth, do not preclude the attainment of water quality standards for dissolved oxygen, and pH, and do not result in impairment of the designated beneficial uses for the SR-HR TMDL reach. The derivation of these targets is discussed in detail in Section 3.2.

The aesthetics, agricultural water supply, domestic water supply, recreation, and salmonid rearing/cold water aquatic life beneficial use designations apply year round and the associated nutrient and algae targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) from May through September.

Common Sources

There are many sources and conditions that contribute to phosphorus in the environment. Phosphorus can be present as a constituent of certain rock types (silicious igneous rock) and in the mineral *apatite*. A 1974 inventory of the nations waters (US EPA, 1974a) found that the mountains along the southeastern border of the Snake River, which form its headwaters, contain some of the world's richest phosphate deposits, including the Phosphoria formation which was deposited about 230 million years ago during the Permian period. This deposit, which extends from Idaho into western Wyoming and southwestern Montana, contains the largest known reserves of phosphate rock in the world (Alt and Hyndman, 1989).

The environment itself can also be a factor in the phosphorus levels occurring within a region, as the climate, pH of natural waters and the presence of other substances that may adsorb or release phosphorus (Hedley *et al.*, 1995) can all potentially affect phosphorus levels. However there are also anthropogenic (man-made) nutrient sources. Applied fertilizers in farming or landscaping, the duration and density of livestock grazing, the creation of artificial waterways and water levels through irrigation and water-management practices, and the presence of sewage and septic waste (treated and untreated) in the surface, subsurface and ground water of a region often represent significant contributions to the phosphorus concentration in an area. All of these sources exist to one extent or another in the SR-HC TMDL reach.

Natural sources of nutrients include indigenous wildlife and wildfowl that utilize the watershed. While these populations are relatively stable throughout much of the year, substantial increases in some populations are observed with spring and fall migration patterns. Fluctuations in the levels of pollutant loading in other watersheds in North America, specific to migrating waterfowl have been identified. In some cases this additional loading is especially noticeable as migration effects are directly correlated with surface water and wetland areas within the watershed.

Nitrogen occurs in the environment in a variety of sources and forms. It can be present as a mineral constituent of certain rock types, as a result of the decomposition of plant and other organic material, in rainfall, as a component of agricultural or urban/suburban runoff, and as a constituent in treated or untreated wastewater from industrial, municipal, or septic discharges. The Rock Creek Rural Clean Water Program (Rock Creek, Twin Falls County, Idaho) found that processes involving applied fertilizers and the plowout of alfalfa were major contributors of nitrogen (Clark, 1989). In addition, the air is composed of about 80 percent nitrogen gas. As stated earlier, cyanobacteria (blue-green algae) can use atmospheric nitrogen at the surface-water interface or the nitrogen dissolved in the water as a source of nitrogen to support growth. Therefore in water systems dominated by cyanobacteria (blue-green algae) nitrogen is not often targeted as a factor for reduction to achieve water quality improvements. Reducing watershed-based sources of nitrogen is not usually a successful treatment option in these systems.

Both physical and chemical processes impact the transport and availability of phosphorus in the SR-HC TMDL reach. Physical processes (wind and water movement) dominate in the transport of phosphorus contained within or adsorbed to sediment and particulate. Chemical processes (change in water chemistry such as dissolved oxygen or pH levels) dominate in the transport of dissolved phosphorus to the system, and in the transformation of phosphorus from one form or state (i.e. free or adsorbed) to another, within both the transport pathway and the water column. Both of these processes represent primary sources of phosphorus input to the SR-HC system.

2.2.4.4 pH

General Concerns

pH is an indicator of the acidity or alkalinity of a system as measured by the hydrogen ion activity in the water. A pH value of 7.0 is neutral with values from 0 to 7 being acid and those from 7 to14 being alkaline. Extremely acid or alkaline waters can be problematic. Extreme levels of pH can be directly toxic to aquatic life. Even at less extreme levels either acid or alkaline conditions can cause chemical shifts in a system that result in the release of metallic compounds from sediments in acid conditions or increased ammonia toxicity and release of sorbed phosphorus under alkaline conditions.

Water Quality Targets

In order to meet the water quality criteria of both states, a pH range of 7 to 9 units has been established as a target for this TMDL process to support designated aquatic life beneficial uses within the SR-HC TMDL reach. Because the SR-HC TMDL reach provides habitat for fish (including salmonids) and other aquatic life, it is important that pH levels be in the appropriate range to provide full support for aquatic life. The target range is based on pH in the critical aquatic environment. Most natural, unpolluted waters will have pH ranges that meet this criterion.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated pH targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round.

Common Sources

In the SR-HC TMDL reach, pH could be altered to a small degree or in a localized area by acidic or alkaline industrial or municipal wastes, ammonia production during organic matter decomposition, agricultural runoff, or by excessive algal growth due to the carbon dioxide released during respiration. However, in this reach, pH is also buffered by sodium, calcium, and magnesium salts (carbonates) dissolved and/or eroded from the landscape and delivered as sediment and bedload, so changes, when they occur, are usually small.

2.2.4.5 Sediment

General Concerns

Sediment loads can influence turbidity, nutrient concentrations, the absorption of toxic substances, and bed form characteristics. Sediment distribution through water-based transport is essential in many ecological processes (e.g. fertilization of land through annual flooding), but increased sediment loads, e.g. as a result of an extreme meteorological event (such as heavy rainstorms inducing erosion, sandstorms blowing solids into the sea) or human activities (removal of vegetation cover, increase of stream velocities through canalization), can have severe negative impacts on an aquatic ecosystem (NRCS, 2001).

Total sediment loading is composed of suspended sediment and bedload sediment. Suspended sediment encompasses that fraction of solid particles small enough to be held suspended in the water column for extended periods of time and at low flow velocities. Bedload sediment consists of large particles that are moved only during high or extreme flow events and moderately sized particles that are small enough to be frequently entrained by moderate flows but large enough to settle out of the water column at lower flow velocities (NRCS, 2001).

Both suspended sediment and bedload can have negative effects on aquatic life. Many fish species are adapted to high suspended sediment levels that occur for short periods of time as such events are common during natural spring runoff. However, longer durations of exposure to high levels of suspended sediment can interfere with feeding behavior, damage gills, reduce available food, reduce growth rates, smother eggs and fry in the substrate, damage habitat and in extreme cases eventually lead to death. Eggs, fry and juveniles are particularly sensitive to suspended sediment, although at high enough concentrations adult fish are affected as well. Since all fish life stages are listed as designated beneficial uses in the SR-HC TMDL reach, the levels of suspended sediment and their potential affect on aquatic life are of concern.

Newcombe and Jensen (1996) reported the effects of suspended sediment on fish, summarizing 80 published reports on suspended sediment in streams and estuaries. For rainbow trout, lethal effects, which include reduced growth rate, begin to be observed at concentrations of 50 to 100 mg/L when those concentrations are maintained for 14 to 60 days. Similar effects are observed for other species. Adverse effects on habitat, especially spawning and rearing habitat, were noted at similar concentrations.

Suspended sediment concentrations are generally reported on a dry weight basis. However, to determine characteristics and sources, suspended sediment dynamics should be assessed (Chapra, 1997). Sediments originating from the drainage basin are primarily inorganic with a low carbon content and higher density (about 2.65), and often increase in the water column during runoff events. Sediments originating instream (from primary production) are organic with a higher carbon content and lower density (less than 1.25), and often increase in association with algal blooms. The concentration of organic sediments (and potentially their affects) can be underestimated because of their lower density. These organic sediments can accentuate problems of low dissolved oxygen since they become part of the material that is decomposed, consuming oxygen from the water column in the process.

The majority of data collected to date in the SR-HC TMDL reach are measurements of total suspended solids (TSS) rather than total suspended sediment (SSC). Turbidity data are also available. Little direct inorganic sediment information is available. Total suspended solids data have been used as a surrogate for the assessment of sediment within this system. More detail on the data available to the evaluation of sediment within the SR-HC TMDL reach and the comparison of TSS and SSC data used for this selection of targets is available in Section 3.5. It should be kept in mind that both TSS and SSC values may include algae and other organic matter that do not directly correlate with inorganic sediment concentrations in the water column.

Bedload sediment can also adversely affect aquatic species. As sand and silt wash downstream, they can cover spawning gravels. This increases cobble embeddedness in the streambed. If it occurs during incubation or while small fry are using the spawning gravels, this sediment covering can reduce intergravel dissolved oxygen (IGDO) levels and smother eggs or juvenile fish. Accumulation of sand and silt on stream bottoms can also directly limit the availability of spawning gravels, thus reducing habitat for salmonid and other bed spawning species. Bedload deposition also acts to fill in pools within the stream channel, thus reducing or eliminating cold water refugia important to cold water aquatic life during periods of high water temperature. Organic suspended sediments can also settle to the bottom and, due to their high carbon content, can lead to low intergravel dissolved oxygen.

Water Quality Targets

Sediment problems for both Oregon and Idaho have been assessed through the interpretation of narrative criteria based on impacts to aquatic life. Numeric targets established to support designated beneficial uses within the SR-HC TMDL reach have been based on an understanding of sediment transport and delivery within this system and research carried out in systems with similar climate and geology. Current guidelines established by other TMDL efforts recommend less than or equal to 80 mg/L concentration for acute events lasting no more than 14 days, and less than or equal to 50 mg/L concentration for acute events lasting less than 60 days. The Lower Boise River TMDL (IDEQ, 1998a) established these concentrations for support of designated beneficial uses in the Lower Boise River drainage. Similar targets have been identified by the SR-HC TMDL. Total suspended solids targets of less than or equal to 80 mg/L concentration for acute events lasting no more than 14 days, and less than or equal to 50 mg/L concentration maximum monthly average have been identified as protective of the salmonid rearing/cold water aquatic life beneficial use designations. Additional information on the identification of these targets is available in Section 3.5.

Sediment loading within the SR-HC TMDL reach is also of concern because of the attached pollutant loads (mercury, pesticides and nutrients) that the sediment carries. In the SR-HC TMDL, sediment (TSS) targets and monitored trends will function as an indicator of changes in transport and delivery for these attached pollutants.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated sediment targets apply to the mainstem Snake River in the SR-HC TMDL reach between RM 409 and 272.5 (Oxbow Dam), year-round.

Common Sources

Common sources of sediment within the SR-HC TMDL reach are predominantly erosion-based as well as from instream biological productivity. Sediment may originate from natural causes such as landslides, forest or brush fires or high flow events; or anthropogenic sources such as erosion from roadways, agricultural lands, urban/suburban stormwater runoff and construction sites. Irrigated agriculture has been identified as a source of sediment in many tributaries to the Snake River both above and within the SR-HC TMDL reach. Sediment loads within the system are highest in the spring when high flow volumes and velocities result from snowmelt in higher elevations. While no quantitative information is available, it is recognized that a substantial amount of sediment can be generated and transported relatively long distances by extreme precipitation events such as the January 1997 rain-on-snow event in the SR-HC watershed. It has been estimated that although they occur only rarely, such events can account for the movement of a greater volume of sediment in a single event than would be expected to occur in an entire water year under average conditions (IDEQ, 1998c; BCC, 1996)

However, sediment inputs to the SR-HC TMDL reach are limited to some degree by the highly controlled nature of the watershed. As stated previously, the number of dams within the Snake River drainage has substantially modified the transport and delivery of sediment within the SR-HC system. The controlled nature of flow management in the upstream Snake River and in most of the major tributaries reduces the amount of sediment delivered to this reach. Sediment transport, and the transport and delivery of sediment-bound pollutants are directly associated with increased flow volumes and high velocities. Within the SR-HC watershed, sediment loads are not distributed as randomly as would be observed in a free-flowing system. Instead, sediment tends to accumulate behind structures such as dams and diversions both within the SR-HC TMDL reach and in the upstream and tributary watersheds. This reduces the overall concentration of such sediment and sediment-bound pollutants downstream. However, this process localizes the sediment and pollutant mass, which can then lead to substantial pollutant re-entrainment if water-management practices of the impoundments are altered substantially. Additionally, sediment deposition areas within the impoundments can be altered (and in turn have the potential to alter water quality through renewed availability of previously sealed sediment layers) through substantial drawdown scenarios such as high water year flood control management in Brownlee Reservoir.

The depositional action of these impoundments can also lead to conditions where designated beneficial uses are negatively impacted by a decrease in certain sediment sizes downstream. For example, reduced availability of small and moderately sized particulates downstream may reduce available spawning habitat for some fish species.

While the above processes can result in reduced water quality, impoundments can also act to improve water quality in downstream segments. Often, upstream structures can act as treatment mechanisms to improve water quality downstream, creating a sink for inflowing sediment and reducing delivered loads downstream. However, the agencies prefer to prevent the initial loading of pollutants rather than to depend on such instream retention systems.

2.2.4.6 TEMPERATURE

General Concerns

Temperature is an element of water quality that is key to good fish and aquatic habitat. It is used to determine if water will support warm or cold water aquatic species. High water temperatures can be harmful to fish at all life stages, especially if they occur in combination with other habitat limitations such as low dissolved oxygen or poor food supply. Elevated temperature, as a stressor to adult fish, can result in lower body weight, poor oxygen exchange and reduced reproductive capacity. Extreme high temperatures can result in death if they persist for an extended length of time. Juvenile fish are more sensitive to temperature variations and duration than adult fish, and can experience negative impacts at a lower threshold value than the adults. Acceptable temperature ranges vary for different species of fish, with warm water species being the most tolerant of high water temperatures. The SR-HC TMDL reach contains a wide variety of warm, cool and cold water fishes. The system must therefore be managed to provide appropriate habitat to support designated beneficial uses at those locations and seasons where use occurs for the various species. Criteria have been established for the aquatic life needs of the important cold and warm water species that must be protected. The temperature criteria are usually built around a maximum allowable value that relates to critical life stage requirements. Appendix C contains more detailed information specific to temperature tolerances of fish species found in the SR-HC TMDL reach.

Water Quality Targets

Temperature targets for the SR-HC TMDL were established based on a comparison between the temperature standards for Idaho and Oregon. A detailed description of this methodology is contained in Appendix C.

Temperature targets are based on both Oregon and Idaho temperature standards which include narrative criteria acknowledging that "natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions" (OAR 340-41-120 (11)(c)). To accommodate such systems that naturally exceed the numeric temperature criteria, the Oregon narrative criteria includes the following language. "No measurable surface water temperature increase resulting from [human] activities is allowed in a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 17.8 ^{o}C [7-day average of the daily maximum]" (OAR 340-41-725, 765, 805, and 845 (2)(b)).

The SR-HC TMDL temperature target identified for the protection of salmonid rearing/cold water aquatic life when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is: 17.8 ^{o}C (expressed in terms of a 7-day average of the maximum temperature) if and when the site potential is less than 17.8 ^{o}C. If and when the site potential is greater than 17.8 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources.

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

The SR-HC TMDL temperature target identified for the protection of salmonid spawning when aquatic species listed under the Endangered Species Act are not present or, if present, a temperature increase would not impair the biological integrity of the Threatened and Endangered population, is: a maximum weekly maximum temperature of 13 ^{o}C (when and where salmonid spawning occurs) if and when the site potential is less than a maximum weekly maximum temperature of 13 ^{o}C. If and when the site potential is greater than a maximum weekly maximum temperature of 13 ^{o}C, the target is no more than a 0.14 ^{o}C increase from anthropogenic sources.

When aquatic species listed under the Endangered Species Act are present and if a temperature increase would impair the biological integrity of the Threatened and Endangered population then the target is no greater than 0.14 ^{o}C increase from anthropogenic sources.

The temperature target for salmonid spawning is applicable only when and where salmonid spawning has been identified to occur within the SR-HC TMDL reach. This target applies to the Downstream Snake River segment (RM 247 to 188) only, and is specific to those salmonids identified to spawn in this area, namely fall chinook and mountain whitefish.
Temperature targets for salmonid spawning in the SR-HC TMDL apply during critical time periods for salmonid spawning only. These targets apply only to that portion of the SR-HC TMDL reach below Hells Canyon Dam (RM 247 to RM 188). Critical time periods for salmonid spawning in the Downstream Snake River segment of the SR-HC TMDL reach are from October 23rd to April 15th for fall chinook, and from November 1st to March 30th for mountain whitefish. The target therefore applies from October 23 through April 15.

As was mentioned in Section 2.2.2.2, salmonid spawning has been designated to occur in specific tributaries to the SR-HC TMDL reach. Salmonid rearing/cold water aquatic life is designated to occur in the mainstem Snake River in the SR-HC TMDL reach. Because the SR-HC TMDL reach provides habitat for fish (including salmonids) and other aquatic life, it is important that the temperature levels be appropriate to support them. These targets are based on temperatures in the critical aquatic environment. They are protective of cold water aquatic species as well as salmonid rearing life stages.

Although there are data that show temperatures that exceed the temperature target in the reach, there is considerable information (data as well as anecdotal) available that indicates there were temperatures over this target historically, even when aquatic species were present in healthy populations (prior to dam construction) (USFWS, 1957, 1958, 1960 and 1968). One explanation for this could be the occurrence of colder water refugia during periods of high stream temperatures in the bulk of the waterway. Such refugia could be present around springs and at the mouth of tributaries to the SR-HC TMDL reach.

An alternative explanation is that there have always been high water temperatures in much of the SR-HC TMDL reach and the lower portions of its tributaries due to high summer air temperatures, high solar radiation, and low summer flows. Native fish species may have adapted to these conditions and are capable of surviving and thriving under temperature conditions with summer water temperatures in excess of those defined by the targets identified in this TMDL either with physiological or migration adaptations. Cold water refugia may have been more extensive than it is today due to anthropogenic effects in tributaries, the upstream Snake River and dam construction. It is assumed that a combination of more extensive cold water refugia and an evolutionary temperature tolerance may have acted to support healthy population levels historically.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated temperature targets apply to the mainstem Snake River in the SR-HC TMDL reach (RM 409 to 188) year-round. The salmonid spawning beneficial use designation and the associated temperature targets apply to the mainstem Snake River in the Downstream Snake River segment (RM 247 to 188) of the SR-HC TMDL between October 23 and April 15.

Common Sources
Temperature increases in the SR-HC TMDL reach are potentially the result of a combination of sources. Most probably, the process of natural heat exchange through high air temperatures and direct solar radiation affects on the water surface play a major role in high summer water temperatures. Both the mainstem Snake River and the inflowing tributaries drain basins that experience hot, dry climates (See Figure 2.1.3 for average daily air temperatures in the SR-HC TMDL reach). In addition, native vegetation in all but the headwaters of most drainages is relatively low growing and sparse (providing little shading on major tributaries). These environmental factors play a major role in water temperatures in the SR-HC TMDL reach. Additional temperature influences may stem from industrial and agricultural inputs, diversions and impoundments, straightening and diking of stream channels, loss of riparian vegetation, and other anthropogenic modifications to both the mainstems Snake River and the inflowing tributaries, however, while these inputs may have a substantial effect on localized temperatures, they most likely represent only minor influences on water temperatures in the mainstem Snake River. A more detailed discussion of temperature influences is available in Section 3.6.

2.2.4.7 TOTAL DISSOLVED GAS (TDG)

General Concerns
Elevated total dissolved gas levels (above 110 percent of saturation) are known to have a detrimental effect on aquatic biota. High concentrations of gas in the water can result in *gas bubble trauma* in fish. This condition occurs when air bubbles form in the circulatory systems of salmon and resident fish. Gas bubble trauma results when the sum of the dissolved gas pressures exceeds the compensating pressures of hydrostatic head, blood, tissue, and water surface tension. Signs of gas bubble trauma have been observed in trapped adult fish below Hells Canyon Dam (IPCo, 1999b, 1999f).

Water Quality Targets
Both Oregon and Idaho share the same numeric water quality standard for total dissolved gas (TDG). Oregon State standards require that the concentration of total dissolved gas relative to atmospheric pressure at the point of sample collection shall not exceed 110 percent of saturation, except when stream flow exceeds the ten-year, seven-day average flood flow (OAR340-41-725, 765, 805, 845 (2)(n)). Idaho State Standards require that the total concentration of dissolved gas shall not exceed 110 percent (110%) of saturation at atmospheric pressure at the point of sample collection (IDAPA 58.01.02.250.01.b). Idaho State Code further states that the Director has the authority to specify the applicability of the gas supersaturation standard with respect to excess stream flow conditions (IDAPA 58.01.02.300.01.a). The target for the SR-HC TMDL reach is therefore established as a total concentration of dissolved gas that shall not exceed 110 percent of saturation, except when stream flow exceeds the ten-year, seven-day average flood flow.

Total dissolved gas exceedences have been documented to occur within the SR-HC TMDL reach, however, no segment of the reach is listed for total dissolved gas exceedences by either the State of Oregon or the State of Idaho.

The Hells Canyon Complex is licensed by FERC, and requires 401 Certification from both the State of Oregon and the State of Idaho. These re-licensing processes represent a very broad and capable effort to identify the full extent of total dissolved gas concerns, designated use support needs, and viable treatment options associated with total dissolved gas violations in the Hells

Canyon Complex. In addition, these processes will act in an enforcement capacity to provide reasonable insurance that total dissolved gas improvements by the Hells Canyon Complex will be realized and designated beneficial uses fully supported.

The salmonid rearing/cold water aquatic life beneficial use designation and the associated total dissolved gas target applies to the mainstem Snake River in the SR-HC TMDL reach between RM 285 (Brownlee Dam) and RM 188, year-round.

Common Sources
Elevated total dissolved gas levels are the result of spilling water over spillways of dams. Spill at Brownlee and Hells Canyon Dams is the only source of elevated total dissolved gas in the SR-HC TMDL reach.

2.2.5 Other Regulatory Water Quality Efforts Occurring in the Snake River - Hells Canyon TMDL Reach

Several upstream and tributary TMDLs have been completed, others are currently in process; still others will be initiated in the near future that may affect the water quality in the SR-HC TMDL reach. The current pollutant reductions identified by existing TMDLs have been incorporated in the loading analysis for the SR-HC TMDL to the extent possible. TMDLs currently in progress or scheduled for the near future will build on allocations developed by the SR-HC TMDL.

All of these efforts will, collectively, be evaluated to determine future water quality benefits and long-term trends within the SR-HC TMDL reach. These assessments will be critical to the ongoing SR-HC TMDL process in order to monitor if identified reduction mechanisms are sufficient or if additional reductions may be necessary to meet water quality standards.

Similarly, the FERC re-licensing process for the Hells Canyon Complex is proceeding concurrently with the SR-HC TMDL process. IPCo filed a draft FERC license application in September 2002. This application included proposed protection, mitigation and enhancement (PM&E) measures, some of which address water quality impacts associated with the project. The final license application and PM&E measures will be filed on or before July 31, 2003. In addition, section 401 of the CWA establishes the requirement for State certification of proposed projects or activities that may result in discharge of pollutants to navigable waters. States evaluating a 401 Certification application are authorized to condition any granted certification to assure compliance with appropriate water-quality related requirements of state law. IPCo expects to file a 401 Certification application with the states of Oregon and Idaho on or before July 2003 as a part of its re-licensing obligations.

The SR-HC TMDL process will be completed and the final document submitted to the US EPA prior to the completion of either the FERC or 401 Certification processes. Because mitigation of the environmental impacts of hydropower projects is currently recognized as part of both the FERC and 401 Certification processes, it is expected that both of these processes will build on the recommendations for water quality improvements identified within the SR-HC TMDL and its accompanying implementation plan. In this manner, some of the water quality-based PM&E

measures identified within the FERC license application and similar measures identified within the 401 Certification process are expected to be driven by the requirements for changes in management, maintenance or other appropriate implementation mechanisms identified as the responsibility of the hydropower projects by this TMDL and its accompanying implementation plan.

Implementation of these measures will be evaluated along with the implementation of water quality improvement projects for both point and nonpoint sources. An assessment of the collective effectiveness of all implementation measures will be incorporated into the ongoing TMDL process to accurately assess trends in water quality conditions, and identify those issues that still need to be addressed by identified point and nonpoint sources.

Photo 2.2.0. Water quality monitoring in the mainstem Snake River near Ontario, Oregon (near RM 369) circa 1939 to 1940, relatively low water years. Photo from the collection of Dr. Lyle M. Stanford.

In addition to the processes discussed above, the SR-HC TMDL reach is home to two species of snail (the Idaho Spring Snail and the Bliss Rapids Snail) and several fish species (chinook and sockeye salmon as well as steelhead and bull trout) currently listed under the Endangered Species Act (ESA). Habitat for these species may be affected by water quality conditions within the SR-HC TMDL reach. In setting instream water quality targets and load allocations to meet appropriate state water quality standards, habitat requirements for these species will be evaluated within the SR-HC TMDL process. The SR-HC TMDL process, along with the TMDL-based water quality recommendations carried through into the FERC and 401 Certification processes for this system will address to the extent possible, the water quality needs of endangered species within the system. Every effort will be taken to ensure that the management actions of this TMDL are consistent with the ESA.